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Microtome Sliced Block Copolymers and Nanoporous Polymers as Masks for Nanolithography

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Introduction. Block copolymers self-assembling properties are commonly used for creation of very fine nanostructures [1]. Goal of our project is to test new methods of the block-copolymer lithography mask preparation: macroscopic pieces of block-copolymers or nanoporous polymers with cross-linked phase are sliced with microtome and pattern is transferred from flakes to substrate by plasma etching.

Experimental Section. Group of Self-organized Nanoporous Materials in Technical University of Denmark has developed series of block copolymers of Polybutadiene-b-Polydimethylsiloxane (PB-b-PDMS) of different morphologies with period of structure ~24nm [2]. It was shown that mechanical shear-alignment of cylindrical block copolymer with PDMS cylinders in PB matrix orients cylinders in the direction of shearing. Subsequently PB is cross-linked by dicumyl peroxide to fix cylinder orientation. Afterwards PDMS can be chemically etched from the PB matrix by tetrabutylammonium fluoride in tetrahydrofuran and macroscopic nanoporous PB piece is obtained. Both block-copolymer piece and nanoporous polymer piece were sliced with cryomicrotome perpendicular to the axis of cylinder alignment and flakes with hexagonal pattern were transferred onto silicon wafer for plasma etching.

Results and Discussion. After flakes had been removed hexagonal arrays of holes were observed on the silicon. Quality of observed structures depends on etching time. The longer etching time is the large optimal thickness of flake for pattern transfer. For short times there are no structures under the thick flakes (60-120 nm thick) but thinnest flakes (25-35 nm thick) give nice hexagonal patterns on the surface. On longer times holes under thin flakes start to merge. Thicker flakes have large surface roughness and on longer times of etching patterns appear only under the certain parts of thick flakes and are not continuous. Although flakes from block copolymer are thinner and more uniform in thickness than flakes from nanoporous polymer, quality of patterns under nanoporous flakes appeared to be better than under block copolymer flakes. Etching of PDMS cylinder not uniform along the surface and it also etches substrate and thickness difference affects results more than in nanoporous flakes case.

- [1] R.A. Segalman, Mat. Sci. Eng. R, 48, 191 (2005).
[2] L. Schulte et al, Polymer, 52, 422 (2011).